SEWER VENTILATION

AND

SEWAGE TREATMENT.

BY

R. HARRIS REEVES.

PRICE HALF-A-CROWN.

PUBLISHED BY
SINCLAIR, TWEEDIE & CO.,
13, ELDON STREET, LONDON, E.C.
1890.


SANITARY INSTITUTE OF GREAT BRITAIN.
SALUS GENERIS HUMANI.

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PREFACE.

In placing before the public the results of experiments, investigations, or work of a technical nature, the usual practice is to do so through a publisher of scientific literature and copies of the work are forwarded to editors of scientific journals for criticism.

Investigations and experiments in sewage matters are very costly, yet when this expense has been incurred, the cause of an evil proved, and appliances, or plans provided for its prevention, you cannot insert the names of the manufacturers or details of such appliances without getting some hostile criticism. The medium of informing the public of the results must be the book; the cost of appliances or plans, manufacturers, &c., the advertisement columns. In a little work I published some time ago I purposely kept out of its pages any reference to appliances patented by myself. The criticisms on that work were very favourable, but one critic said "the

work was evidently written to sell a certain instrument." This certainly was not the case. Now this pamphlet is expressly written to bring before the public my system of sewer ventilation and sewage treatment. It is published and sold by Messrs. Sinclair, Tweedie & Co., who are supplying the apparatus, and contracting for the application of the system, so that the public can have all the facts before them.

The opinions expressed in the papers this year, during the occurrence of epidemics, have not been very complimentary to the students of sanitation, and the public have loudly blamed bad sanitation as the cause of the zymotic outbreaks. Engineers, or those who have made sanitation their study, are not always to blame for such results. It must be admitted that the greatest improvements have been made by those men who have or have had the practical working of a drainage system. Yet when a new scheme is required, through the increase of a district, the services of these men are not secured, but those of some eminent engineer, whose experience was gained in a different class of work. Thus when the results are not satisfactory the sanitary profession is blamed, whereas it is the public themselves or their representatives who are really to blame.

The researches of scientists such as Pasteur, Budd, Saunderson, Tyndal, Bastian, Lester and Dallinger on the one hand, and Dibdin,

Tidy, Dupré and others, on the other, have made it imperative that we should change our methods of procedure in dealing with a sewerage system. We must adopt new plans, but these must be founded on sound principles.

It is a curious fact that invariably when a new plan is submitted to a public body, and even some engineers, the first question is "Where has it been tried?" The merits or soundness of the scheme are never gone into, but schemes of known unsoundness are adopted. How would an architect look if when he had prepared drawings and plans of a church, mansion or public building, those who employed him were to say, "Your plans are very nice, the outline and details of your elevations are charming, yet before we can decide to place the work in your hands you must erect the building to let us see if it will suit us?" Under these circumstances, therefore, I have inserted somewhat fully the opinions of those who have seen and experienced the results from the working of my system.

On some days this year the treatment at Frome (through alterations) has not been in operation.

Should any doubt the accuracy of my statements on sewer ventilation, simply because they are contrary to their ideas, I would say test for yourselves, but be accurate and use good instruments in doing so.

I would thank those who have so favourably criticised the results of my earlier experiments, and particularly Dr. Park, in his correspondence in the *Glasgow Herald* on the purification of the Clyde.

R. H. R.

November, 1889.

SEWER VENTILATION

AND

SEWAGE TREATMENT.

HITHERTO it has been the practice to treat sewer ventilation as one subject, and sewage treatment at the outfall as another; but from the results of experiments I have made during the last few years I find that the more perfect the ventilation of sewers is, the less work is involved in treating the sewage at the outfall tanks. In fact the sewage difficulty or nuisance is caused by the sewage having to travel through a stagnant atmosphere in the crown of the sewers, and it is the want of fresh air, or oxygen in this atmosphere, that is the cause of the nuisance.

Experts, when speaking or writing on the London sewage question, treat the outfall works and the pollution of the Thames as the most defective part of the sewerage system, and point to it as being of the greatest danger to the public health. This is an error, and is evidently due to the fact that in the summer months the foulest gases are given off. Now in summer the sewage

invariably travels through a colder atmosphere than in winter, and this atmosphere remaining for months almost stagnant assists decomposition which produces foul sewage and sewer gas. When these gases are liberated or set free to mix with the air on the surface in large volumes, at certain conditions of the atmosphere we invariably get zymotic outbreaks. This not only applies to sewers, but to all stagnant air over putrid matter. If we closely study the subject of the London sewage, and apply the experiments hereinafter given, or the natural laws which govern the elements, sewage and air, we can come to no other conclusion than that it is the greatest mistake which could be made to think that in perfecting the works at the outfalls, the sanitary condition of the Metropolis would be improved sufficient to warrant the immediate outlay. It is beginning at the wrong end. You allow putrefaction to begin at the extreme ends of the system, and continue the whole length of the sewers (some seventeen miles), then when it is decomposed thoroughly at its arrival at the outfall, the process of treatment is heavier and more costly. Good precipitation of sewage and a clear effluent appear to be the goal to which sanitarians are rushing, and the treatment of sewage in the streets, where it more seriously affects the health of the community, is entirely overlooked.

In the autumn months we invariably get many cases of diarrhœa, fever, or an epidemic of one of the zymotic diseases. If we take the meteorological laws which govern the changing of the air over sewage in transit, and compare the influences that this air has on the sewage, and the sewage on the air under such circumstances, the origin of these periodical outbreaks can be easily seen, and authorities having acquired this knowledge can avert much sickness as well as epidemics in their district by taking precautionary measures which will prevent their occurrence.

In support of this I will take an area on the Metropolitan district, or a district under one surveyor. Its area is about 900,000 square yards. Now this year, between June the 16th and July the 9th, the air over sewage in the sewers *remained stagnant twenty-two days.* When this was driven out, a computed volume of 567,875 cubic feet of air (or sewer gas) was discharged into the atmosphere as explained in Plates 1, 2 and 3 In this district we have, deducting the space occupied by the buildings, a layer of foul air which contains volatile gases that lower the system and "lay it open for the reception and elaboration of zymotic influence."

Should those gases and germs be discharged on a day when the weather was bright and the wind brisk, then danger to health would be somewhat nullified, but on a dull day with a depressive

atmosphere, or during a fog, their power on the health of the inhabitants must be seriously felt. If the whole volume of air over the London sewage was computed, and its action on the sewage, and the action of the sewage on the air was clearly defined, the authorities would very soon begin reforming the sewage system in the streets in preference to the outfall.

From the earliest ages medical and other historians tell us that most epidemics followed volcanic or atmospheric disturbances on the earth's surface. Modern writers, speaking of germs, say they remain quiescent for months—that no one would believe they were in existence, but in a night the air of a district becomes charged with countless multitudes of them, not one of which was to be found previously.

Now, it must not be supposed that these germs attain their vitality or numbers instantaneously. Their habitat is in putrid matter, and they multiply in gases from it, which form an atmosphere of unequal weight, and one which is deprived of portions of its oxygen. This atmosphere retains its additional weight through being in contact with water, and kept at a less temperature, and is only removed when a volume of air of greater power is forced against it. It is then germs are scattered broadcast. The atmosphere of the locality is charged with them, they are breathed into the system, or taken in with water and food,

and epidemics occur. Thus, volcanic disturbances do not in themselves produce epidemics, but release, by the additional pressure caused by volcanic force, and mix up, gases containing germs which have been held for a long time in contact with liquid.

In a paper I recently read before the Sanitary Congress, at Worcester, I briefly treated some of the defects in our existing systems of sewer ventilation and their relation to public health; but as the facts contained in that paper were only a portion of those I have met with in working on this subject, and the time allowed (twenty minutes) being insufficient to deal with it properly, I have been advised to give a more detailed reason why our different systems of sewer ventilation fail at seasons of the year when their action is most needed. Also a full detailed account of the means I have worked out to obviate the evils shown, and others which suggest themselves.

SEWER VENTILATION.

The necessity of sewer ventilation is to prevent the intercepting traps from being syphoned. If a sewer or drain is not provided with openings for the admission of air it will ventilate itself. On the rising of the sewage it will blow the air or sewer gas through the traps in volume according to the amount of displacement, and on the lowering of the sewage, or the emptying of the drain, it will suck the water out of the trap having the least dip or resistance, and fresh air will flow into the sewer through this trap which forms the inlet. The numerous openings that are now made on lines of sewers were made with a view of diffusing the bad gas formed in the sewers over as large an area as possible, and the theory that was laid down was that the more numerous the openings the less sewer gas would be evolved. In practice this has not been confirmed, and the reason of this will be found by a careful study of the working of the different systems of ventilation during the variations of atmospheric pressure. This variation of pressure, or increase, or decrease of temperature on the surface as compared to that of the sewer, forms one of the motive powers which create our air currents. In my experiments I have frequently found that bad

sewer gas (being heavier in gravity) is frequently floating in the sewers from one district to another, and at times the whole of the gas that is leaving the sewers of a district is through one or two gratings.

These gases, especially those at low levels, have as much effect in setting up a rapid decomposition in fresh sewage, as bad sewage itself. Thus many analyses that have been made as to the cost of chemicals are unreliable, as the sample would be of a totally different character if the whole system were under chemical treatment.

Undoubtedly the best form of ventilation is to provide air inlets in the vertical shaft, with openings or gratings level with, and in the centre of, the road. By this plan, on the lowering of the sewage, fresh air is at once admitted into the sewer without friction; but although we may construct openings that will supply air without friction, the air on the surface will not go down the shaft into the sewer in a volume to be of any service for ventilation except during the winter months.

Plate 1 shows longitudinal and cross sections of such sewers with ventilating shafts. At the bottom sections at A is shown the ordinary sewage level. When the sewage is not affected by rainfall it usually rises in the morning, when the slops are emptied, to the level B. Thus we get forced out daily about one-fourth of the air in

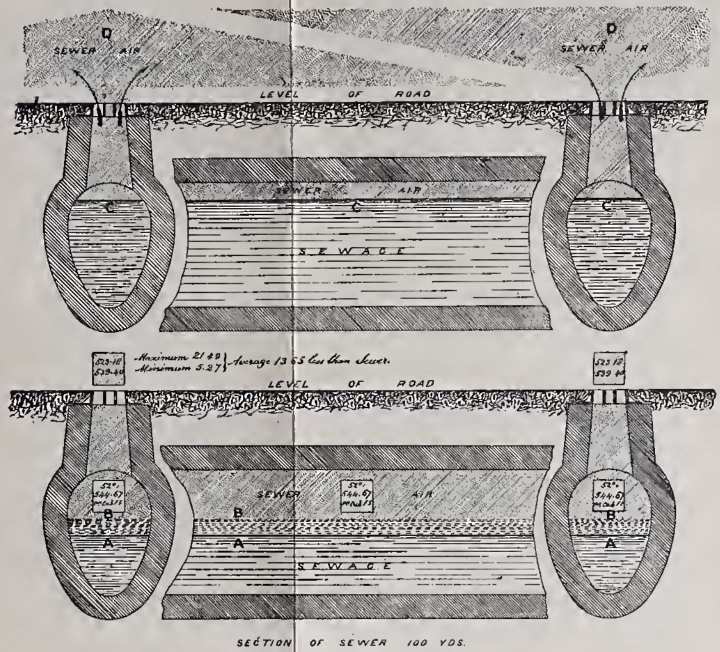
each sewer; but this only changes the air near the ventilating shafts. The bulk of air between the shafts is not affected, and we only get a fresh supply into the sewers when they fill through an excessive rainfall. The temperature and weight shown by the cubes, both on the surface and in the sewers, was that of August the 9th, 1889. The highest on the surface was 73 degrees = 523·18 grains per cubic foot in weight, and the lowest 57° = 539·40 grains per cubic foot.

Now the temperature of air in the sewers being 52° = 544·67 grains per cubic foot, there was an average, during the twenty-four hours, of 13·65 grains less pressure per cubic foot in the whole of the atmosphere on the surface, as compared with that of the sewer. When the sewers, filled by the rainfall, as shown by the top section, Plate 1, a volume of *sewer gas* ten feet in width, as shown, *was driven out to mix with the atmosphere.*

By a careful examination of the chart* Plate 2, which shows the weight of air per cubic foot on the surface as compared to that of the sewers, the rainfall, and a weekly average of the temperature (taken in the shade); we can form an accurate idea of the quantity of fresh air that we get in sewers, during each month of the year.

Although it is generally known that wind

* These readings of the thermometer and rainfall were kindly supplied me by Mr. J. H. Steward, 406, Strand, London.



D
SEWER AIR
LEVEL OF ROAD
SEWER AIR
C
SEWAGE
523.18
539.40
Maximum 21.49
Minimum 5.27
Average 13.65 less than Sewer.
B
A
SECTION OF SEWER 100 YDS.

PLATE I

currents are formed by the mixing of air of different temperatures on the earth's surface, this fact seems to be entirely ignored in our various systems of ventilation.

In the month of January, 1889, the lowest temperature on the surface (daily average of two readings) was $28\frac{1}{2}^\circ$. This gave an additional weight of 26·25 grains per cubic foot to the air on the surface in excess of that of the sewers. The highest temperature registered was $48\frac{1}{2}^\circ$, which gave 3·86 grains per cubic foot more pressure than the air of the sewers.

In February the lowest temperature was $29\frac{1}{2}^\circ$ pressure, or 25·05 grains more than the sewer. The highest was $51\frac{1}{2}^\circ$, whilst that in the sewer was 52°, the weight was only 0·55 grains, or, in fact, the atmosphere was nearly evenly balanced. The rainfall was frequent during this month, so that no effects from sewer gas would be experienced.

In March the lowest temperature was 28°, giving an excess pressure on gratings of 26·84 grains per cubic foot, and the highest 53°, giving a pressure of 1·18 grains for one day less than the air in the sewers.

In April the lowest average was $42\frac{1}{2}^\circ$, giving a pressure of 10·32 grains per cubic foot on the gratings. The highest was $58\frac{1}{2}^\circ$, which, being $6\frac{1}{2}$ less than that of the sewers the force of air as a motive power, was *nil*. This occurred

on the 19th, 20th, 27th, 28th, and 30th, and *it is now that we begin the manufacture of sewer gas.*

In May the lowest temperature registered was 50½°, which gave a pressure of 1·63 grains. The highest 72°, which reduced the pressure on the surface to 20·5 grains less than that in the sewers. It was only for two days that any pressure was given on the surface gratings. Now, although the weight on the surface was less than that of the sewer, a supply of fresh air was taken into the London sewers by the frequent occurrence of a rainfall during this month.

In June the lowest temperature was 52°, which gave an even balance of the air, both on the gratings and in the sewers, but this only occurred for one day, the highest being 71½°, with a pressure of 20 grains less than the air in the sewers. For the first six days there was no rainfall, but rain fell in sufficient quantities up to the 12th to displace the air in the sewers; but from the 12th up to the 8th of July no rainfall of any consequence is recorded. *Thus the air remained in the sewers* as shown in Plate 1, Section 1, *for twenty-two days.* In fact, during this time *the sewers formed retorts for the manufacture of sewer gas.* This is confirmed by referring to the chart, Plate 2: by the high temperature and no rainfall towards the end of the month of June, and the following extract:—

NOTE.—The firm vertical lines below datum shows the weight of the atmosphere (grains per cubic foot) on the surface in excess to that of the sewer.

The firm vertical lines above shows the weight of atmosphere, less that of the sewers.

The dotted line shows the rainfall in inches.

The irregular line shows weekly average.

CHART COMPILED FROM DAILY READINGS OF THE THERMOMETER
SHOWING PRESSURE ON GRATINGS

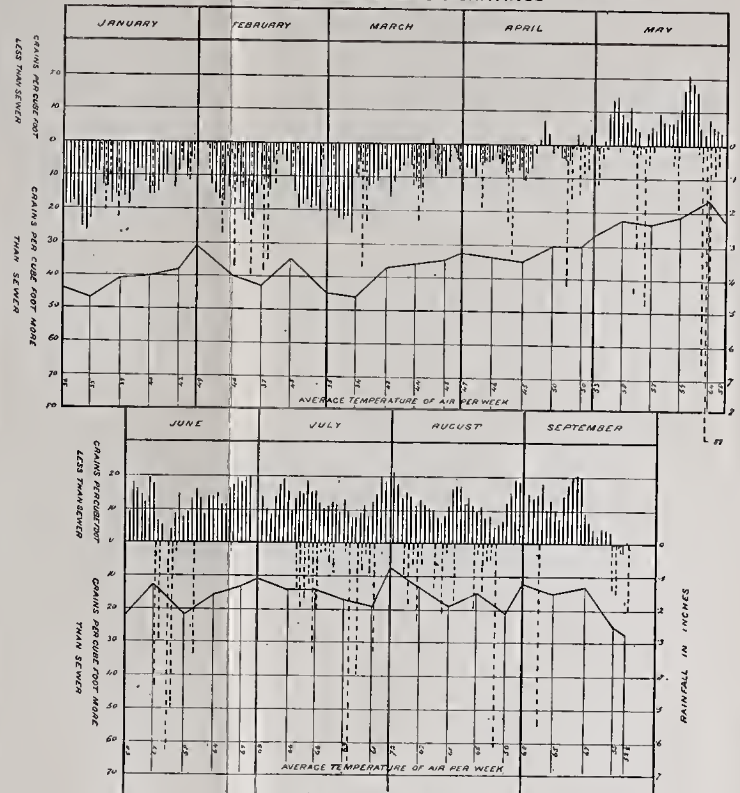


PLATE 2

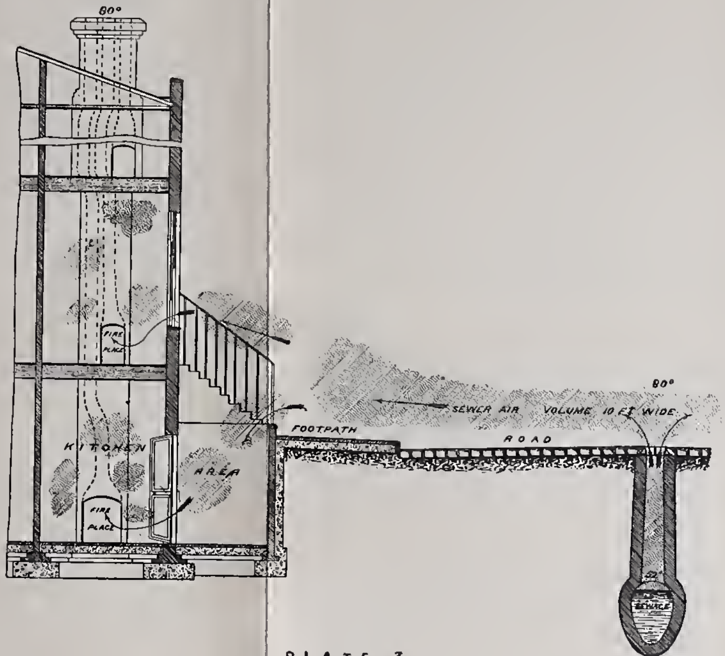

80°
FIRE PLACE
KITCHEN
FIRE PLACE
AREA
FOOTPATH
SEWER AIR
VOLUME 10 FT WIDE
ROAD
80°
SEWAGE

PLATE 3

"ECHO," JUNE 28TH, 1889.

Overpowered by Sewer Gas.

"Two workmen who went down a sewer yesterday, in Stamford-street, Waterloo-road, nearly met their death by the fumes of the sewer gas. When rescued the men were unconscious, and one of them remained in that state for nearly an hour."

The lowest temperature registered in July was 59°, which gives a less pressure of 7·35 grains to that of the sewers. The highest was 71½°, giving 20 grains less than that of the sewers. A rainfall occurred on ten successive days, from the 8th to the 18th of July, and the effect would be to cause the sewage to rise in the sewers as shown on Plate 1, Fig. 2, and *the sewer gas which had been forming for twenty-two days would be driven out, and become diffused into well appointed houses.* The manner in which this gas finds it way into houses is shown in Plate 3.

The effect of these gases on the public health must be left to those who have made scientific researches on the germ theory of disease to determine. It is, however, certain that within a few days after this volume of sewer gas was mixed with the atmosphere, an Epidemic of Typhoid occurred in the West-end of London, for on August 19th Lord Granby questioned the President of the Local Government Board as to the prevalence of Typhoid Fever in this district.

Medical writers state that the microbe of typhoid is produced by impurities from overcrowding, but supposed to find its way into the

system by water, milk, or some other liquid. Sewage finding its way into water and milk has been known to produce it. What over-crowding could produce such an atmosphere, as would occur from this discharge of sewer gas?

Although the microbe of typhoid has been found and cultivated, it has not yet been known to reproduce the disease, and the prevailing opinion that it is conveyed by liquids, does not in the least disprove that its development may not be found in this volume of sewer gas.

We know that water, milk, and food, will soon become putrid if in contact with foul gases. The cause of this putrefaction is due to an increased development of organisms, and the greater the development of organisms the greater the amount of bad gases evolved. Consequently *the mischief must be traced to the gases which form the favouring atmosphere for the growth of microbes, and supply the germs.*

In working on this subject I have noticed some very remarkable things occur with reference to sewer gas. When the gases from a sewer are given off, after many days of high temperature on the surface and these pass from a grating in the centre of the road opposite a silversmith's shop. the silver articles, although placed in supposed air-tight cases, will daily tarnish, but disinfect those gases and the tarnishing ceases. Mr. Dibdin, in his report to the Metropolitan Board of Works on

the effects of deodorizing the sewage at the pumping station, Pimlico, notices the same thing. He states, "since this deodorizing station has been in operation the smell in the engine room and outside has almost disappeared. Complaints at the Grosvenor Road Station have ceased, and the brass in the engine room does not become tarnished."

Gases produced of sufficient power to thus affect metals must have injurious effects on the system. Dr. Tyndal, in his work on floating matter in the air, states, "that air which has passed through the lungs is known to have lost its power of causing putrefaction." Professor Lister ascribes the immunity from danger to the filtering power of the lungs. Dr. Tyndal proves that in filtered air putrefaction cannot take place. These facts taken together prove that the lung is the barrier against living organisms. Now if this barrier is weakened by the effects of such gases that will destroy metals, although not probably containing organisms, this weakening allows a free passage of the various microbes into the system. Therefore, to prevent this barrier from giving out or being useless we must, to stop epidemics, prevent gases being formed on the whole of our drainage systems.

In explaining the epidemic which occurred in August, the authorities were not certain as to the source of the evil, as they say, "the interest of the

epidemic, in this instance, is that it should have visited the houses of the well-to-do. Here is a disease commonly ascribed to unhealthy surroundings showing itself in quarters of the town, and in individual houses which are not only not insanitary in any ordinary meaning of the word, but are doubtless provided with the very best appliances that engineers can devise and plumbers can make." Unfortunately this incidence of Typhoid Fever upon well-appointed dwellings is nothing new.

It was suggested that a leakage in the main drain was the cause, "as there had been many bad smells rising from the ground especially at night." The theory that leakage in the drains was the cause did not hold good, as the smells were experienced at considerable intervals.

This evidence is very confirmatory of the fact that *the epidemic of August was caused solely through the non-ventilation of the sewers and the production of sewer gas.*

The lowest temperature in July was 59°, giving a pressure of 7·35 grains less than the air of the sewers. The highest, 71½°, with a pressure of 20 grains less than the sewers; but during three parts of the month rainfall occurred almost daily, and this would form a motive power for air circulation in the sewers.

In August the lowest temperature registered was 57°, giving a pressure of 5·27 grains less than

the sewers. The highest was $73\frac{1}{2}^{\circ}$, which gave 21·68 grains less than the sewer. The rainfall during this month was experienced on fifteen days: there being no rainfall on the last six days.

In September the lowest temperature was $49\frac{1}{2}^{\circ}$, or a pressure of 2·78 grains more than the sewers, but this occurred at the end of the month. The highest was 72° with a pressure 20·5 grains less than the sewers.

From August the 25th to September 3rd no rainfall occurred, thus sewer gases were being made for eight days and then given off. From September 3rd to the 25th, the gases remained in the sewers twenty-one days, through no pressure being on the gratings, but it was on the 27th, 28th, and 29th that the pressure increased about two grains in weight to that of the sewers. *It is a singular coincidence that our hospitals were at this period being filled with fever cases.*

Although we can accurately show the periods at which the gases are driven out of the sewers by the rainfall, we cannot determine the time they are driven out of sewers from which the rainfall is cut off, or from house sewers or branch drains; but we may assume that the cases of typhoid now taking place in different parts of the country, do undoubtedly owe their origin to the taking into the system these bad gases, which are produced solely by bad ventilation.

Many persons at the present day calculate the

motive power of ventilation by the wind pressure, or by the power of appliances for producing currents; also the difference in the temperature of one volume of air as compared to that of another. Now, in sewers constructed similar to this section we have, or fancy we have, a power in the wind pressure on the gratings. Supposing the wind pressure over the gratings gave 1-lb. additional pressure per square foot, this in itself would be sufficient to overcome the difference in temperature between the air on the surface and that of the sewers; but unfortunately it is pulling this additional 1-lb. *at all gratings*, consequently its power is lost, and we do not get what we anticipate.

There is another power of ventilation that is often calculated, viz., the diffusion of the atmosphere on the road surface with that of the sewer. I find that this is one of the things that are very misleading. Those who are working on the subject of sewage treatment know that many experiments made in the laboratory do not work out satisfactorily in the works, and this is one of them. Take two glass vessels, one containing a colder and heavier air, and the other a warmer and lighter one, and connect them, you can accurately calculate the time it will take for the air in both vessels to become the same weight and temperature, but this will not apply to sewers or drains. In the experiment where the

heavier air is not in contact with water as you have it in the sewers, the water keeping the temperature low prevents the diffusion, and so the experiment to be of any value should be made with a bottomless vessel containing the heavier air in direct contact with running water. It is the *running sewage*, which prevents this diffusion of air at the upcast shafts.

A practical illustration of the way in which the circulation of air is blocked in flues, which are similar to sewers, by one body of unequal weight being unable to remove another that is in contact with water, is shown in a very remarkable manner by the following case, which occurred in connection with chimney shafts. Some difficulty was experienced by Mr. H. Walmsley, of Failsworth, near Manchester, in getting a draught to a chimney 200ft. high attached to a silk mill. It appeared to the owners to taper too much, and a Mr. J. D. Wright, who was engaged on the work, gives his experience as follows:—

"Mr. Walmsley wished to know whether I could take 30ft. or 40ft. off the chimney, which I undertook to do, and undertook to do the work without stopping the machinery. There were thirty-seven boilers connected with the works, and not one of them would draw.

"I commenced operations as usual, gained the top, and commenced to cut a course out right through the chimney, about 40ft. below the top.

This was a very difficult job to do. I supported the top of the chimney I wished to remove on slip wedges, having a lever attached to each wedge, and a rope from the end of the lever to the ground. When the chimney was cut three parts round, I came down, and the tackle answered the purpose of pulling down the 40ft. When the lever ropes which were attached to the wedges were pulled upon, all came out, leaving the top of the chimney in a tottering condition. Six or seven men then pulled on the main tackle, which swung the 40ft. of brickwork all in a lump to the ground. By this operation the diameter of the chimney was enlarged 1ft., *but the draught was not much improved*. On further investigation, I found out a secret that I never thought of. The chimney was fully 500 yards from the boiler-house, and the main flue was led through a field which was level. I had some suspicion that there might be some damp or stoppage in the flue. This belief I communicated to Mr. Walmsley, who instructed me to improve the draught at any cost. I engaged a number of labourers, and opened up a part of the flue, in which *I found about 9in. of water*. I had the water taken out of the flue, and cast a drain to carry it off in future. On Monday morning the steam was got up in half the time it took before. and the draught was so powerful that it shook the very doors of the furnaces. Both I and my employer regretted

that we had not discovered this before we took down 40ft. of brickwork."

Now, if a stream of water running across a flue was sufficient to neutralise the work of a shaft 200ft. high, and the heat generated by the furnaces of thirty-seven boilers, how can we expect to get ventilation to sewers by shafts 50ft. high, without furnaces, and when the air in the horizontal flue (the sewer) is in contact with water the whole distance? Some years ago I noticed that during the summer months the air in sewers formed a body which worked in currents unequal and independent to that of the ventilating shafts.

Persons who are sceptical as to the regularity of the temperature kept up in sewers, and who have not time to investigate for themselves, can easily be satisfied by noticing the heat during winter weather dissolving the snow at openings for ventilation, and testing the temperature in the summer at the surface of the gratings and the bottoms of the manholes.

Systems of ventilation applicable to a building would not be effective when applied to sewers. The reason of this is, there are motive powers working in the sewers which form air currents greater than the motive power of appliances for ventilation, consequently the lesser power must give way to the greater, and thus ventilation becomes inoperative.

VENTILATION OF SEWERS BY SHAFTS. (OR "HIGH LEVEL BLOW-OFF PIPES"!).

CONFLICTING opinions exist in the minds of experts as to the value of these shafts when erected for sewer ventilation. By referring to the chart of pressure (Plate 2) it will be seen that the power of the surface atmosphere would be of more or less value for this purpose during the months of January, February, March, April, October, November and December.

If the sewage was travelling at a slow velocity in the sewers to which these shafts were attached, and these shafts were tested during these months, a current would possibly be found to enter the gratings and leave the top when water was not flowing from the branch drains; but during the months of May, June, July, August and September, it is against the laws of nature to expect any fresh air to go up them. As an example, take the section of sewers as shown on Plate 4, Fig. 1. On a sewer two miles long the shafts are fixed for ventilation at intervals of 160 yards. Now, on the surface of this length of sewer a barometer would record a pressure at the lower level of 29·98 lbs. per square inch, or 57 grains more per cubic foot than at the top level, which would be

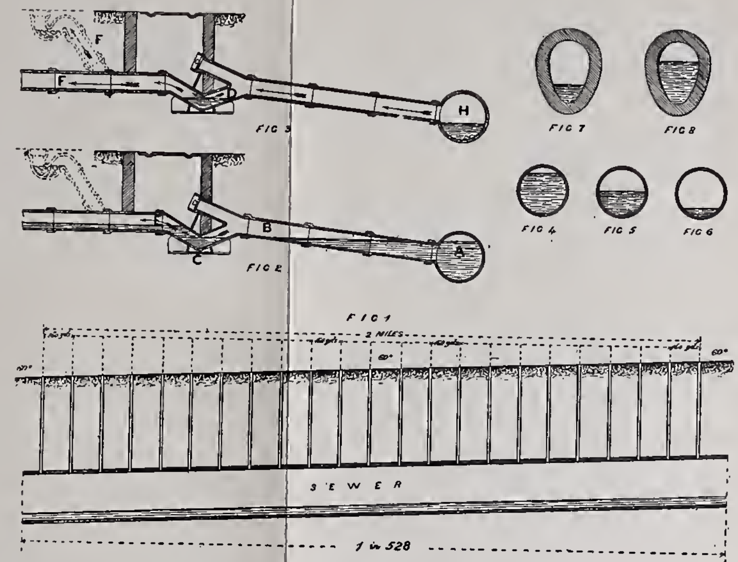

F
F
H
FIG 3
FIG 7
FIG 8
B
A
C
FIG 2
FIG 4
FIG 5
FIG 6
FIG 1
2 MILES
60°
60°
SEWER
1 in 528

PLATE 4

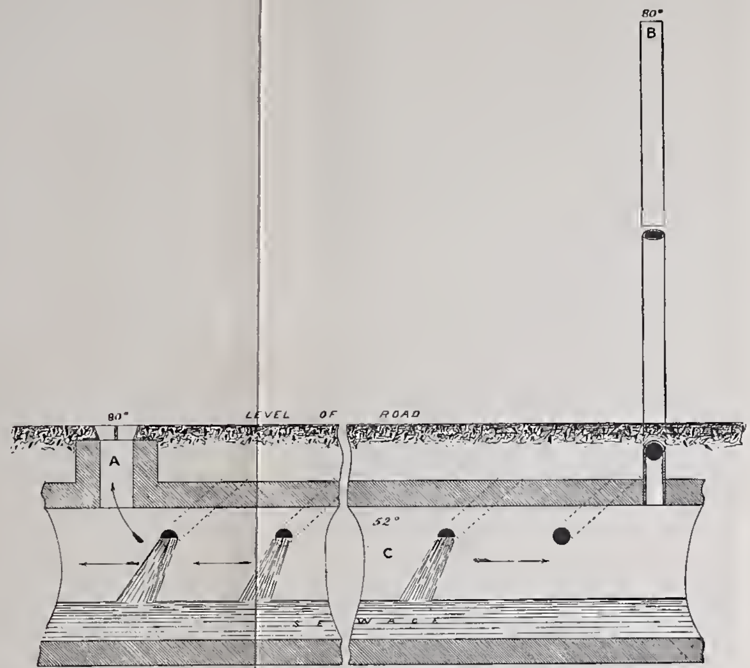


PLATE 5

29·96 lbs. per square inch. The pressure being greater at the lower level would give a current of air from the bottom to the top.

A round sewer 1′-6″ diameter would contain 18,660 cubic feet of air, and this quantity would enter the bottom and leave the top continuously if it were not for the temperature, and the sewage flowing into it from branch drains, as shown in Plate 5. The sewer is more or less filled, as shown in Plate 4, Figs. 4, 5 and 6. By the filling of the sewer with sewage the pressure of air at the different levels as recorded by the barometer is neutralized, and *the air is driven out of gratings near the sewage flow* in proportion to its volume velocity.

In oval sewers, shown in Fig. 7 and 8, the area of friction is very small when the sewage is low, thus not seriously affecting ventilation; but in the rushing of sewage from branch drains into the sewers the air will be leaving the nearest gratings, whilst it will be coming in at those situated farthest away. *On the ceasing of the rush of sewage from the branch drains, the air will be entering the sewers in quite a reverse way, upsetting previously formed theories of sewer ventilation.* The motive power for this is when the sewage is at the level, shown in Fig. 5, an area of 15,840 superficial feet of water acting against the air of the sewer, drawing it from the top to the bottom. This surface of sewage friction on

the air forms one of the greatest motive powers in producing air currents in sewers and drains.

Given a 12-inch pipe sewer which fills at A, Fig. 2, as is often the case during a heavy rainfall, or even during the discharge of a flushing tank, partial stoppage will take place. A portion of the worst air on a system already formed in the drain B, while the filling of sewer A is proceeding, is driven through the trap C by the lifting of the water at E, through which it passes, and in doing this the air is washed, and would probably leave its worst germs in the liquid. But when the cause of the drain filling had stopped, it would commence to lower itself, and in doing this the sewage would act as the plunger of a pump, creating a vacuum behind it, and drawing the water out of the trap C, *leaving a free passage* at D, Fig. 3, *for the sewer air (which may have been for months oscillating to-and-fro in contact with the sewage) to enter the branch drains* F, *and through them the houses.* Even the mere act of flushing sewers will produce this vacuum, and so lower the water in the trap. In summer time this air in the various branch drains attached to the main sewer, forms the worst gases that can be found in any part of a system of drainage. The reason of this is that the water passing the intercepting trap from the branch drains drives out into the sewer a corresponding amount of air to the level to which

the sewage rises. When this flushing ceases, instead of fresh air being admitted to take the place of the air driven out, as is the case in the sewers, *sewer gas returns from the main sewer.* This process goes on as long as the seal of the intercepting trap remains perfect, but only for so long, and to this fact much sickness which occurs at unaccountable times may be attributed.

Every now and then a person may complain of a bad odour near his house, and this is nearly always caused by the syphoning of the traps. To show the evil of allowing these traps to empty, let us suppose that between two street ventilators there are ten branch drains from the houses on either side, connected to the sewer, of which the traps of only nine have been re-charged. The tenth being empty will allow all the gas from the air space H. in the sewer, to pass into the house as soon as the sewage rises. Therefore it is important to flush the drains of unoccupied houses frequently.

Plate 5 shows a form of shaft ventilation which is very widely adopted on sewerage schemes. Taking the sewer C to be 80 yards long between the supposed inlet shaft A and the upcast shaft B, you will usually find many branch drains entering the sewer in this length. The water flowing from these, when in use, causes the ventilation to be reversed by driving the air in the sewer C towards the grating A, and consequently A forms the

outlet and B the inlet. This will happen if the flow of water from the branch drains should disturb only 1-2,000th part of the air in the sewer by creating a greater power than that exerted by the upcast shaft B. There is another variation which also takes place, viz.: the contraction and expansion of the air space in the sewer by the rise and fall of the water level.

This reversing of the current of air would not be of so much consequence if each section of sewer were trapped off from the other as recommended by some engineers, but *even then the sewer gas would be expelled into the street through the inlet grating* A, to the annoyance of persons passing by. An accurate idea of the working of this ventilation could be formed if two fans were placed in an empty section and set to work forcing in and drawing out air in an irregular manner. The fans would form the motive power in the same way as the sewage does in practice.

By referring to the temperature of 80° on the surface and at the top of the shaft, and 52° in the sewer, there is a difference of 28·28 grains pressure per cubic foot less on the surface than in the sewer, thus no air currents can be produced in this section other than those formed by the sewage in transit. Some engineers, to overcome the irregularity of the air currents, have closed down the gratings, and erected high shafts

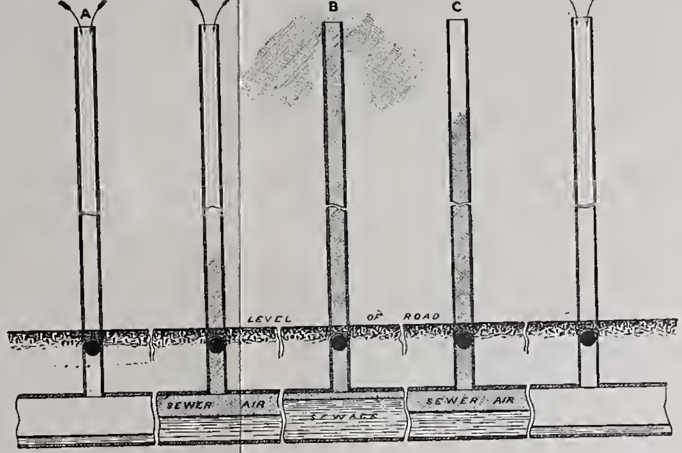


PLATE 6

as in Plate 6, which have been fancifully termed by some "high level blow-off pipes!"

These are intended to stop the complaints of sewer gas escaping into the streets, but no better plan could have been devised for creating a stagnant atmosphere. *This arrangement is simply turning a sewer into a cesspit.* The system of ventilation is the same as in a cesspit, caused by the rise and fall of the sewage. If the distance from the sewer to the top of these shafts averaged 120 feet, and the diameter of the shafts was 6 inches, they would contain 145 cubic feet of air. *Before any sewer gas could come from the sewer into the atmosphere this 145 cubic feet of air must be driven out of them, and it would take a displacement of 906 gallons of sewage to pass from the branch drains into the sewer before any gases could be driven out into the air.* When the sewage lowers to this extent *the fresh air entering at the top does not go into the sewer, but only re-fills the shafts.* Thus in working, instead of sewer gas going into the atmosphere at the street level on the rising of the sewage, it *is simply oscillating up and down the pipes. Should a trap from any cause become unsealed on a sewer so ventilated, sewer gas of the worst kind would leave the sewer through this trap and enter the house.*

Some persons fancy that by placing a ventilator; which is supposed to give an extra lifting power by the action of the wind; on the top of

the shaft, an air current would be formed. This is an idea which will lead to one of the worst evils in sanitation. If a ventilator which would, in a still atmosphere, produce a current of 60 feet per minute, was placed on shafts marked A, B and C, they would simply be useless. All experiments have proved that the wind passing over an open pipe at a high level, gives as much lifting power as a pipe on which a ventilator is fixed. Therefore, assuming that we get this current, by the aid of the ventilator, which we know we do not, there would be a pulling power alike on *all* the shafts (or each one pulling against the other) on a system during wind currents, and this would bring the ventilation to the same as that of a still day, when no currents are experienced. The ventilation produced, and the manner in which the gas leaves the sewer, is shown in Plate 6 by the shading. (See Appendix II.)

Another form of ventilation which has been tried, is the moving of the air in sewers by furnaces, or fans driven by any motive power, which form extractors, having air gratings to form inlets between them. Experience proves that the rush of air in sewers will syphon the traps, and when the trap nearest the furnace or fan has become syphoned, the fresh air rushes through this trap, and through the furnace or fan, leaving the other parts of the sewers stagnant. This was proved by experiments at the Clock

Tower of the House of Commons, and has since been verified.

To enumerate the number of experiments I have made to overcome these evils, might perhaps be interesting, but would take up too much space.

REEVES' SYSTEM OF VENTILATING SEWERS, AND THE CHEMICAL TREATMENT OF SEWAGE.

THE principle on which this system is based is not of recent origin. It is the result of years of experiments. Many of the details are new, but the soundness of each detail has been well tried. The difficulty experienced in bringing out any new plan is great, and to place before the profession and the public a plan which is contrary to already accepted theories, requires some explanation.

Many years ago I was engaged in H. M. Service on works which compelled me to test a drainage system and the ventilation of the house drains, to discover the origin of a typhoid outbreak. The results of these tests, which extended daily over four months, proved conclusively that the theories held by sanitarians with reference to air currents, were wrong. Take for example the ventilating pipe from a w.c. It was the custom, twelve years ago, to carry the pipe, full size, up to a few feet above the eaves of a building, and to place an intercepting trap between the house drain and the sewer. A ventilator (supposed to have extracting powers) was placed at the top of the soil pipe. These were erected by thousands, *yet, with a sound*

intercepting trap, not a cubic foot of air has ever passed up these pipes since their erection. They were simply like uncorked bottles, and the testing gave reverse results to what were expected. Instead of air going out, $2\frac{1}{4}$ cubic feet entered the top of the soil pipe each time of flushing, and this was driven through the trap. The trap it would go through was the one which had the least dip or seal.

When the vertical tube was introduced, a number of scientists met at St. George's Hospital and noticed that a steady flow of air entered the building through the tubes. The *Times* stated that it entered in volume as required by the inmates, and the tube was considered the motive power of this regular supply. At this time I was carrying on experiments, and fixed one of these tubes where the temperature on the inlet was lower than on the outlet, with the result that the air flowed in an opposite direction.

Since that time I have carried out hundreds of experiments, all of which prove the correctness of the statements I have made with reference to the existing systems of sewer ventilation and sewage treatment.

Before describing my system of ventilation and sewage treatment it would, probably, be as well to insert the opinions of others as to the soundness of my plan.

In an article in the *Builder*, April 29th, 1888.

Mr. Phillips, C.E., stated that "the complete ventilation of sewers had never yet been properly accomplished." In the next issue the following letters appeared :—

"THE VENTILATION OF SEWERS."

Sir,—Mr. John Phillips commenced his article [p. 296, *ante*] quite accurately when he stated that "the complete sanitary ventilation of sewers had never yet been properly accomplished."

The desired object will most certainly not be attained by the adoption of Mr. Phillips's "suggestion."

The isolation of sewers by means of the water trap is not new ; I applied that method eight years ago, and have more recently isolated several miles of sewers in this district in the same manner.

The first experiment tried in Wimbledon was on a sewer passing up a hill with a steep gradient ; the trap was placed at the junction of the sewer with the main outfall, and it was provided with a so-called air-inlet, brought to the surface and provided with an iron grating : at the end of the sewer a 6-inch pipe was carried above the roof of an adjacent building. So far, Mr. Phillips's plan was anticipated.

I thought at that time that the air would pass into the sewer at the "air inlet" and out at the top of the hill. A week had not elapsed before I found I was wrong ; the direction of the air in the sewer was prevailing down the hill and out at the "inlet." I commenced observations and found the same thing was occurring in other sewers ; when further traps were inserted, therefore, means were provided to admit of the gases coming down to escape at levels sufficiently high to prevent inconvenience.

I was satisfied that continuous experiments were necessary, and I commenced a series, the observations being made

with regard to the direction of flow of the sewer air, its temperature with that of the sewage, and the external air. These have been carried on for some months, and will be continued for a sufficiently long period to enable me to throw some light upon the subject, when the results will be made public.

In the meantime I will merely say that Mr. Phillips's conclusions as to effect of temperature are entirely erroneous, so far as the Wimbledon sewers are concerned, and these do not differ from other sewers in any essential particulars, so far as I am aware.

W. SANTO CRIMP.

Wimbledon, *April* 30, 1888.

SIR,—In the article on the above subject which appeared in your last issue [p. 296], Mr. John Phillips, C.E., states that the "complete sanitary ventilation of sewers has never yet been properly accomplished."

I would wish to state a few facts as to what has come under my attention in connexion with this important subject, not with any idea of controverting Mr. Phillips's theory, but from a sense of fairness to the originator of a system of sewer ventilation tried with success in Tottenham.

In the early part of last year some of the ventilating manholes in the district gave considerable trouble, and complaints of the emission of noxious gases were numerous.

As a remedy, several upcast shafts were erected, but these in most cases proved ineffectual. Indeed, I have frequently noticed that the shaft acted as the inlet and the grating in the road as the outlet.

Eventually the system of sewer ventilation and deodorising of sewer gas, invented by Mr. R. Harris Reeves, was brought under the notice of the Local Board, and it was decided to obtain the assistance of that gentleman. After making

careful observations into the requirements of the district, Mr. Reeves fitted his apparatus to the most offensive ventilators, with the result that, although the sewer air continued to be freely given off, it was quite innocuous, and complaints at once ceased, thus proving that by the introduction of this system the sanitary ventilation of sewers had been accomplished.

This question is so closely allied to the problem of the treatment of sewage that I might proceed to say without irrelevancy that Mr. Reeves does not stop at the ventilation of sewers and deodorising of sewer gas,—he goes a step further and prevents sewer gas being made ; also chemically treats the sewage whilst in the sewers ready for precipitation and manipulation at the outfall.

I recently had an opportunity of visiting Frome, where this system is in operation. In that town there is no smell either at the ventilators or at the sewage works.

The latter was locally known as the "Stinkeries," but now that term is in no way applicable.

C. J. EASTON,
Chief Inspector, Sanitary Dept.,
Tottenham Local Board of Health.

May 2, 1888.

MARYLEBONE SEWERS.

A GRATING on one of the sewers of this district gave off bad gas, six cases of fever and one of cholera were in the street. An apparatus to prevent the making of sewer gas was fixed in this manhole. Result—nuisance and sickness ceased.

Analysis of its working by the Medical Officer of Health and Analyst. Dr. Wynter Blyth :—

Composition of Air taken from manhole in which a Reeves' Apparatus was in action.

	Air taken from manhole at foot of Reeves' Apparatus.	External Air.
	Per cent.	
Oxygen	20·85	20·84
Nitrogen	78·97	79·12
Carbonic Acid Gas ...	·08	·03
Sulphurous Acid Gas...	·10	?

Satisfactory testimonial from H. Tomkins, Esq., surveyor to the Marylebone Board.

ST. GEORGE THE MARTYR.

In the district a bad street existed, sewage from oil refiners, knackers' yards, etc., flowed into it. This was an old experimental London sewer; and after six months working with four apparatus the experiment was stated, by the Medical Officer of Health, to have been highly successful.

Testimonial to this effect also from the Surveyor.

RYDE, ISLE OF WIGHT.

The town sewers being of steep gradient some ventilators had been very offensive, and on these numerous systems of ventilation had been tried. "One ventilator was constantly emitting a stench of a disagreeable character." Since one of my patent apparatus for preventing sewer gas being made, has been fixed, "the air

passes out of the ventilator without the slightest trace of any offensive smell."

These three cases are the most difficult ones to be found in England.

Results as to ventilation and sewage treatment continued on a large scale, will be found in the following report of the experiments carried on during the last three years at

FROME.

Frome is a hilly place of about 10,000 inhabitants, having a number of cloth and silk manufactories, the refuse from which runs into the sewers, making the sewage very foul and difficult to treat.

The sewage works were originally designed to treat the sewage by the lime process, but this was tried and failed, and since that time every known precipitant and chemical for treating sewage has been tried. The whole system was designed and carried out about five years ago by Mr. Ph. Edinger, C.E., and may be described as having plenty of open gratings in the streets, and good machinery for the lime process at the works, but the result was very unsatisfactory, and practically, a failure.

In the summer of 1887, twelve of Reeves' Patent Apparatus were working in the streets, fixed at the principal points of the drainage system. These and the outfall works were visited by the sanitary committee monthly, and

in December of the same year, the Chairman of the Board presented the following Report:—

"REPORT OF MEETING AT THE SEWAGE WORKS.

Eight members of the Board visited the Sewage Works at Leonard's Mill on the 22nd November, with the special object of ascertaining the effect upon the sewage, as it passed out of the tanks, of the application of chemicals to the manholes in the town. The effect at the manholes themselves in deodorizing the sewage had proved very successful, thus removing the just complaints from the escape of noxious and offensive exhalations. The members found equally satisfactory results at the works, there being only a slightly perceptible effluvium from the mass of crude sewage filling three of the tanks, and this on the day of their visit was not of an offensive character. The chemicals were also said to act as precipitants, and this was found to be correct, for since their use precipitation by lime or sulphate of iron has been discontinued, yet a large amount of sludge has been obtained and the effluent in consequence, is clearer. Thus far, therefore, the experiment both in the town and at the works is satisfactory; but the members are of opinion that sufficient time has not elapsed to enable them to speak with certainty upon the scheme, and they suggest that the system be carried on through the summer to see the effect of warm weather with little rainfall,

arrangements being made with the patentees for this to be done."

Feeling assured that I could precipitate the sewage much better by chemicals and give a clear effluent, I obtained permission from the Frome Board to discontinue the use of the machinery, and carried out a series of experiments on the tanks. These lasted some months, and resulted in the Frome Board entering into a yearly contract in September 1888, to treat the sewage in the streets, and at the outfall works. The terms of this contract were, that we guaranteed no sewer gas in the streets, or nuisance from the tanks, effluent, or sludge. That contract has only recently been renewed for another year, and during the year just completed no complaint was made by the Board that the terms of the contract had not been strictly carried out, but on the contrary, the members of the Board who visited the works during each month reported in its favour.

In the spring of this year it was decided to fix eight additional apparatus in the town, making the number twenty in all: (forty is the full number required) and whilst these were at the railway station waiting to be fixed, the works were visited by John T. Harrison, Esq., C.E., one of the Local Government Board Inspectors.

The following extract from a report published in the "Somerset and Wilts Journal" of the

30th March, 1889, will shew that the points claimed for this system have been attained:

"WITH H.M. INSPECTOR AT THE FROME SEWAGE WORKS."

"A notification was received at the Emergency Meeting of the Local Board on Friday last, that John T. Harrison, C.E., one of the Local Government Board Inspectors, would pay a visit to the Sewage Works on the following Tuesday afternoon, and it was arranged that Mr. G. W. Bradbury, the Clerk, and Mr. P. Edinger, Surveyor, should meet Mr. Harrison at the Railway Station and accompany him to the works, where the members of the Board decided to assemble at five p.m. the press being permitted, by special resolution to attend.

"Mr. Alderman Flatman, Chairman; Messrs. C. Bailey, J. Bartholomew, B. Butcher, C. Case, J. Chapman, J. Hodder, and J. B. W. Sheppard. Mr. J. Parsons, Medical Officer, was also in attendance.

"Mr. Harrison on reaching the outfall, at once inspected the receiving tank, pumps, turbine, &c. Proceeding from the rising main the precipitating tanks were visited, three being in use and three at rest. The day was not one of the most favourable for such a visit, for while there were occasional intervals of sunshine, there was a gusty wind that would have conveyed any noxious

smell hither and thither to all parts of the works, had such been perceptible. But standing close to the tanks in full operation the odour was of the faintest possible kind, even to those whose olfactory nerves were not in the slightest degree impaired. Proceeding next to the particular tank from which *the effluent was passing, it was noticed that it was remarkably clear, far more so than the river-water at a little distance.* The apparatus supplied by Messrs. Harris Reeves & Co. for precipitating and deodorizing the sewage were in full swing, and both Surveyor and Medical Officer spoke in the highest terms of its efficiency in each respect. The chemical treatment was explained. The plots of land were pointed out where the sludge from last summer had been deposited. The Inspector was informed that at no time had the smell from this been more than just perceptible.

"The Inspector spoke in derogatory terms of the manurial value of the sludge, but Mr. Edinger said he had obtained thirty-five tons of mangolds from a little more than half an acre of land, being at the rate of fifty-six tons an acre.

"Mr. Parsons, Medical Officer, said that it also considerably lightened heavy clay soil. He found no smell from it last summer and in this he was corroborated by members of the Board.

"On completing his tour of inspection. Mr. Harrison asked for two glasses of liquid sewage

one from the upper part of the town and the other from the receiving tank. In the first place the liquid was comparatively clear and bright, in the second, it resembled a bluish black ink. Both samples were almost odourless, &c."

Shortly after this visit the eight additional apparatus were fixed, and the result noted by members of the Board.

The subject was again discussed at the July meeting and the following is an extract from the proceedings:—

"The Engineer reports:—'With regard to the treatment I find that I can, from the third tank of the set, while a continuous flow goes on, obtain an effluent free from all apparent suspended matter . . . I do not think any other arrangement can be more effectual.'

"The Engineer was further of opinion 'That Harris Reeves' System was the best that had yet been adopted.' Mr. Ames asked 'Do you recommend that the arrangement with Harris Reeves' Co. should be continued another year?' to which the Engineer replied,—'Decidedly.'"

I would only add with reference to the foregoing that during the time the alterations were being carried out, the system was not in full working order.

DESCRIPTION OF IMPROVED VENTILATING APPARATUS, AND THE APPLICATION OF CHEMICALS TO TANKS.

It must not be supposed that the chemical treatment of sewage and sewer air, as thus expressed, means the dribbling into the sewage chemicals to stop the smells that arise from gratings or the works. It means the prevention of sickness, raising the atmosphere, and a large quantity of food consumed, to a higher standard of purity, as well as the stopping of nuisances.

In attending meetings on sewage treatment, either at the Institute of Civil Engineers, Society of Arts, or the Sanitary Institute, I notice that instead of discussing the new points or ideas in the paper read, the authors or representatives of various schemes launch out at once on their own methods of procedure.

One medical scientist is constantly giving the audience his views on a certain sewage farm. If these views with reference to sewage farms were supported by facts such as the following, we should have data to work from, and be certainly advancing in sanitary science :—

Proof 1st.—That the atmosphere surrounding

a sewage farm was not lowered in its standard of purity during the time the sewage which had flowed over the land was drying and becoming decomposed by the influences of the atmosphere.

2nd.—That the springs in the locality, or at a distance, were not affected by the water percolating through the fissures of the earth when separated from the solids.

3rd.—That milk from cows fed on the farm did not set up fermentation quicker, or produce more organisms than milk from cows on ordinary meadows.

4th.—That joints of meat from cattle fed on sewage farms were of the same flavour, and would keep from becoming putrid the same length of time as cattle fed otherwise.

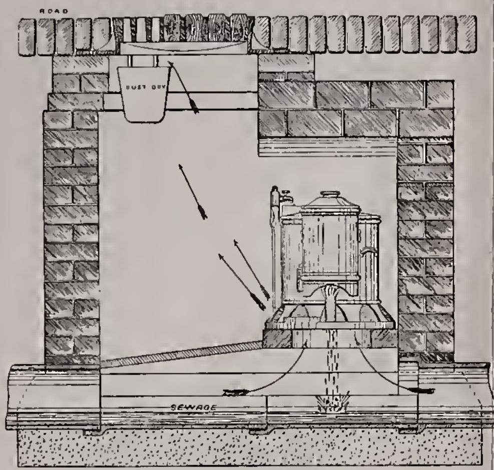
5th.—That vegetables grown on a sewage farm, such as cabbage, celery, radishes, turnips, or mangolds, would, when pulverized raw, keep from fermentation an equal time to that of those grown on rich natural soil.

6th.—That after samples of the whole of these articles of food have been cut up and boiled twenty minutes the liquor from them is of the same consistency, will keep as long, and give an equal test as to purity as liquor produced from similar articles grown from soil not treated with sewage.

If this were done then the beneficial results derived from sewage farms would be established

on a more solid basis than they are at the present.

To those who are in doubt as to the advantages derived from a system of sewerage under proper chemical treatment, I would say that before pronouncing an adverse opinion, test for yourselves and see what benefits are derived, both as regards the purity of the atmosphere and food.



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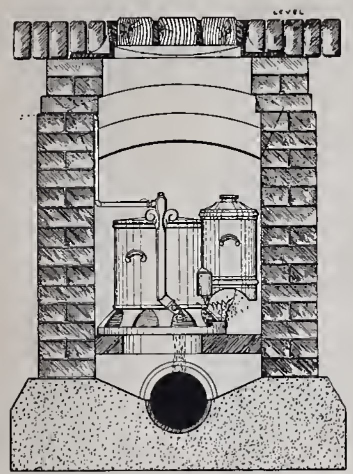

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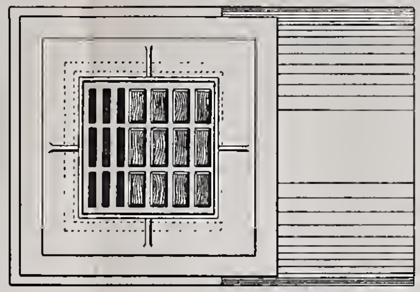
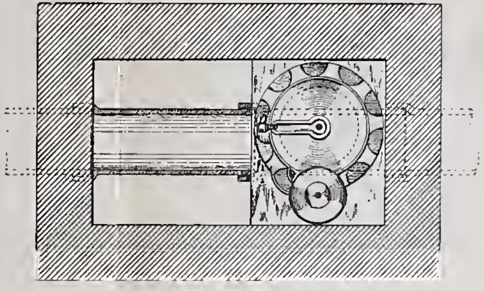


— PLAN AT TOP —



— PLAN AT BOTTOM —

SCALE

PLATE 7.

THE TREATMENT OF SEWAGE IN TRANSIT.

We know that in sewers sewage soon ferments. This fermentation is greatly increased by the mixing of many kinds in transit. The action of one kind on the other assists decomposition, and at times this decomposition goes on very rapidly. To prevent this, decomposition must be arrested in each body of matter as it first enters the sewage system.

This cannot be done without chemicals, and the best results have been attained by manganate of soda and sulphuric acid, not applied in the manner in which it was done by the Metropolitan Board of Works, but by releasing a portion of the oxygen to mix with the air as it enters the sewers, and utilizing the remainder for the treatment of the sewage.

Plate 7 shows the apparatus as applied to street manholes.

The ventilation of the sewers is effected through the ordinary manhole. In the centre wall of the manhole a recess is built to receive the apparatus in the longitudinal section. The air in passing from the street into the sewer, or from sewer into the street, passes with a clear opening and without the slightest obstruction or friction through the apparatus. The apparatus for ventilation is of

simple construction, containing chemicals which act simultaneously on the air in the sewers and on the sewage itself. It is made of chemical ware and the right hand chamber shown on the transverse section is filled with sulphuric acid, and the left hand or larger chamber or cistern is filled with manganate of soda. This is placed in finely perforated trays. The cover of the manganate of soda chamber is a double one, and the inside part is also finely perforated, which allows the water to percolate through. The water enters at the top, percolates through the cover, and the manganate of soda trays, thus forming the solution. This drops on a disc, as also does sulphuric acid. By this action a portion of the oxygen is set free from the manganate in the form of a gas, which keeps the sewers sweet, and destroys any bad gas that may be made in such drains. The solution thus formed is permanganic acid, which overflows into the sewage from the bottom of the apparatus.

It will be thus seen that at every drop of the solution a fresh supply of oxygen is given to the air of the sewers and a disinfectant of the sewage is formed, which stops fermentation or decomposition, and prepares the sewage for further treatment in precipitation at the outfall works.

In scattered districts four apparatus are allowed to each thousand inhabitants.

TANKS FOR A TOWN OF 10,000 INHABITANTS

FOR CHEMICALLY TREATING THE SEWAGE BY REEVES' SYSTEM

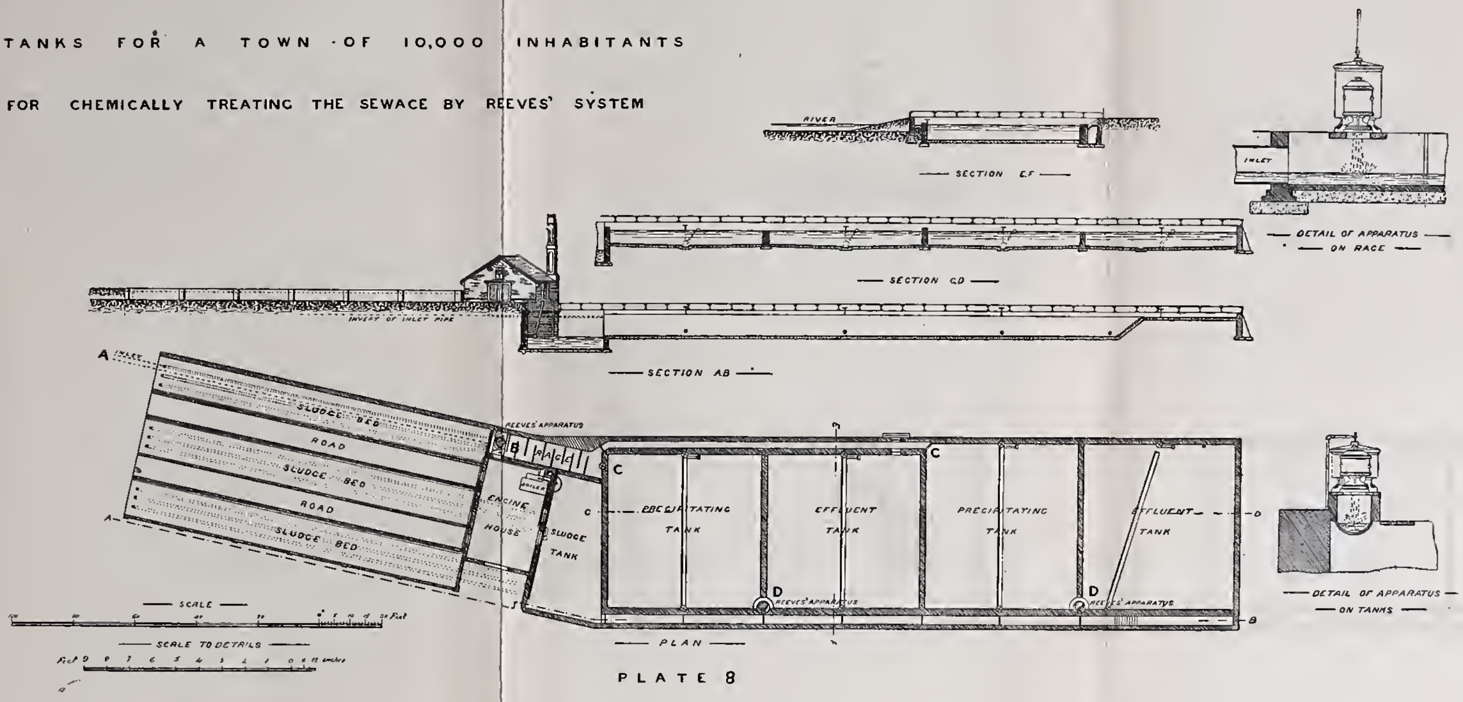


PLATE 8

From the working of the precipitating tanks at Frome, during two seasons, it has been found that some alteration in the construction of tanks is necessary. Plate 8 shows a set of tanks for 10,000 inhabitants designed to precipitate the sewage by means of this chemical treatment.

These tanks are situated near the bank of a river. The main sewer A delivers the sewage into a race at B, over which is an apparatus for additional chemical treatment. It flows into the precipitating tank at C and deposits its solids. The effluent then only containing a small portion of organic matter, is again chemically treated by an apparatus at D, which destroys and precipitates the organic matter, leaving a clear effluent to flow into the river. The expensive process of sludge pressing is dispensed with in this plan.

The sludge is pumped by a small engine on to ventilated beds, through iron pipes, by which it is dispersed evenly over the beds, and is allowed to dry, after which it is cut out in blocks similar to peat, and in this consistency forms a valuable manure for use in dressing land, in a convenient form for transit. Where the whole of the sewage is pumped directly into tanks, a different arrangement is carried out. Existing tanks can be easily altered to meet the requirements of this system.

The cost of chemicals for this system, both in sewers and tanks, has been proved to be less than that of the lime process.

A rule has been laid down by some sanitary authorities that a quick flow of sewage through sewers would produce no sewer gas, and the sewage treatment over land would give no nuisance, &c. Experience does not confirm this, but points conclusively to the fact that to satisfactorily deal with ventilation or sewage treatment it must be done by the aid of chemicals, and this particularly applying to the clearing of the effluent in the tanks, instead of on land by means of filtration. Filtering sewage is a costly process, whether carried on over land or in tanks.

Two towns in England, supposed to possess the very best system of sewerage in existence, as repeatedly quoted by the press, are at the present time experiencing serious inconvenience from their sewers. In the one, the stench from the gratings is most offensive, and at times is also very bad from the outfall tanks; and in the other the schools are closed in consequence of an outbreak of diphtheria. This proves conclusively that the theory that fresh air and land can do the work, is utterly wrong.

Plate 9 shews the system as applied to house drains. The connections and plans of house drains are so varied that a description of a general application only can be given. To a moderate sized London or country house one apparatus fixed in manhole at the junctions of drains as shewn at A would be sufficient, but in very large

PLAN SHOWING REEVES' SYSTEM APPLIED TO HOUSE DRAINS

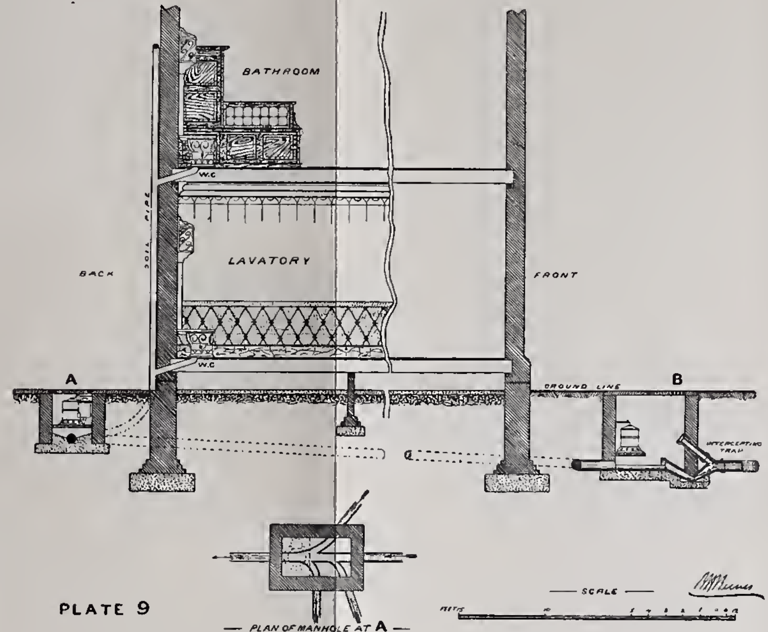


PLATE 9

houses two apparatus would be necessary, one fixed at A, and the other at B, near intercepting trap.

It is imperative that in all cases an air outlet should be provided to manhole B or the drain attached. If this is not done the air will blow through one of the traps on the system, on the flushing of the drain. In certain temperatures and conditions when the fittings are not working this would form the air inlet. In large houses the sewers or drains from intercepting traps to cess-pits, become full or a partial stopping occurs, which, on becoming free or on leaving the drain, sucks the water out of the intercepting trap, leaving a free passage for the air to leave the sewer, pass the trap, and find its way out of the grating. The second apparatus at B is a safe-guard against this, as although the apparatus A would throw off sufficient oxygen for the drains, this would not in large houses be sufficient at all times to purify a bad gas that may pass through the sewer. If the main sewer sewage is chemically treated then this apparatus at B is not essential.

APPENDIX I.

In reviewing the work done by the Metropolitan Board of Works, on the Sewerage Question, from 1880 to 1888, and especially the results obtained from the researches and experiments of Mr. Dibdin, their Chemist, one cannot but think that these are entirely ignored by those scientists who speak on the chemical treatment of sewage, as compared with that of sewage farms, for the treatment of the London sewage.

According to the best authorities, the minimum quantity of *sewer gas* made from the London sewage daily is 1·363·636 cubic feet.

The cost of neutralizing the effects of this sewer gas can be seen by comparing the expenditure of the Metropolitan Asylums' Board in curing zymotic cases, with the additional cost for patients treated at private houses.

The death-rate in London, from zymotic disease, in 1883, was just over 11·000; but in 1884 it reached 13·657, being an excess of 2·599 to that of the previous year.

The expenditure of the Asylums Board when these cases were treated was, in 1880, £252,000; but in 1884 it reached £502,000, or an excess of £250,000.

In 1884, the death-rate from small-pox was 223 per million of inhabitants.

In 1885, 224 per million.

In 1886 (when the sewage was treated), one per million.

In 1887, two per million.

In 1888, two per million.

Thus, by taking the whole facts, it will be seen that it cost *four* times the amount of money to cure the disease as compared with the cost of preventing it.

How can epidemics be stopped when, during the summer months, 1·363,636 cubic feet of sewer gas is, so to speak, being condensed over the London area daily, unless the formation of this gas is prevented.

Taking the requisite area for a sewage farm to be 15 acres per 1,000 inhabitants, London would require 117 square miles in area = 75,000 acres!

If this farm were laid out what would be its cost, and to what extent would the purity of the atmosphere be lowered over the district?

Advocates of Sewage Farms say, "Look at the waste in not applying the sludge to land!" It is a waste, to take it out to sea, and need not be continued. The London sewage difficulty consists in the vastness of the area, and the large amount of matter to be dealt with. Thus the cost of the *partial* application of chemicals to London is not a correct basis, upon which to estimate the cost of treating the whole. What has been done, however, shews conclusively that the solution of the difficulty is alone to be found in chemical treatment.

APPENDIX II.

During the time this matter has been in the press a manufacturer of ventilators has thought fit to caution the public against new forms of sewer ventilation. Now if this critic had shown that he had mastered the rudiments of ventilation, I should have answered him in the journal in which his letter appeared. He says, speaking of ventilating shafts, "let them be raised up by means of proper pipes to above the roofs of houses with fixed exhaust-ventilators on them, and then the sewer gases would get exit continuously." Had he said he could go out and command the wind to blow from east, west, north or south, at his will, he would have been as near the truth in one statement as the other.

I wish it to be distinctly understood that the experiments on the different forms of ventilation here given, are not inserted to depreciate the work of any manufacturer, but when manufacturers make such statements as the foregoing, which are known to be erroneous, those statements must be confuted, as some persons reading them in a trade journal would take them to be facts.

The term exhaust-ventilator *is not applicable* to the appliance. A person may make one of these ventilators, and by placing it on a tube, shaft, or pipe, get an increased current during certain conditions of the atmosphere. Remove the ventilator and the current at once decreases. This at first sight would clearly

demonstrate that the increased current was due to the ventilator. It is nothing of the kind. The wind passing over the top of the pipe cuts off or retards the upward current in the pipe. By fixing on the ventilator this power of the wind to stop the current is prevented, and by this prevention an increased current is secured. Neutralize the wind's influence by any other means and the same result is obtained. In some testings the plain open pipe has given better results than ventilators.

Test these ventilators on a cold day when the motive power is transferred from the bottom of the tube to the top by the atmosphere being heavier in gravity at that point, and it will at once be seen what power this appliance has in *exhausting* air.

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